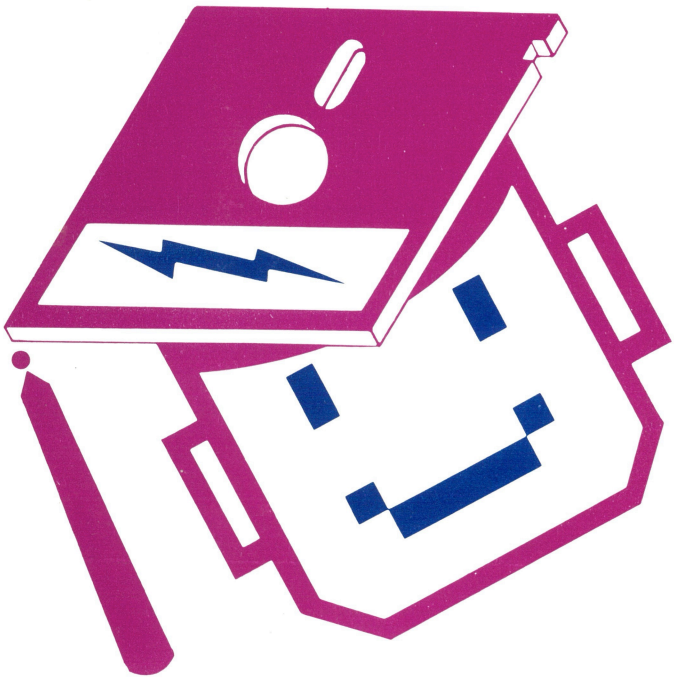
# WATTS IN A HOME



# ENERGY SCHOLAR SOFTWARE SERIES

© 1986 New York Power Authority

" WATTS IN A HOME " IS COPYRIGHTED BY THE NEW YORK POWER AUTHORITY. USE AND DUPLICATION OF THIS PROGRAM FOR EDUCATIONAL PURPOSES IS PERMITTED. ANY COMMERCIAL USE OF THIS PROGRAM IS PROHIBITED WITHOUT THE WRITTEN APPROVAL OF THE NEW YORK POWER AUTHORITY.

Diversi-Dos(tm): Copyright 1983 DSR, Inc.

This disk contains a high-speed operating system called Diversi-Dos(tm), which is licensed for use with this program only. To legally use Diversi-Dos with other programs, you may send $30 directly to: DSR, Inc., 34880 Bunker Hill, Farmington, MI 48018. You will receive a Diversi-Dos utility disk with documentation.

"Apple Computer, Inc. makes no warranties, either express or implied, regarding the enclosed computer software package, its merchantability or fitness for any particular purpose. The exclusion of implied warranties is not permitted by some states. The above exclusion may not apply to you. This warranty provides you with specific legal rights. There may be other rights that you may have which vary from state to state."

"DOS 3.3 is a copyrighted program of Apple Computer, Inc. licensed to Woods Design Associates, Inc. to distribute for use only in combination with Watts in a Home. Apple Software shall not be copied onto another diskette (except for archive purposes) or into memory unless as part of the execution of Watts in a Home. When Watts in a Home has completed execution Apple Software shall not be used by any other program."

"Includes graphics routines from Cat Graphics by Polarware"

"Graphics routines from Cat Graphics by Polarware were written by David Shapiro and are copyrighted 1984 by Polarware. All rights reserved. Cat Graphics and Polarware/Penguin software are trademarks of Polarware."

# TABLE OF CONTENTS


Introduction . . . . . 1

Getting Started . . . . . 3

Running the Program . . . . . 5

Teacher Section . . . . . 11

Pre-Simulation Homework Assignment . . . . . 17

Class Assignment . . . . . 21

Post-Simulation Homework Assignment . . . . . 23

Building a Generator Model . . . . . 25

Constructing a Galvanometer . . . . . 29

Further Reading on Electricity . . . . . 31

Glossary . . . . . 33

# INTRODUCTION

WELCOME TO "POWER CONTROLLER." This simulation puts you and up to two friends in charge of a large power control room for 24 hours (three eight-hour shifts). You will learn about the four different sources of electricity in Wattstown (fossil fuel, nuclear, hydroelectric and pumped storage). You will also learn about the amount of power each source produces and its cost. You must decide which sources to use at different times of the day.

You'll see how the demand for electricity changes at various times during the day and night. If the amount of power you provide isn't enough, you'll cause a brownout or blackout.

When the team completes the three shifts, a chart will appear. It will show:

- the number of blackouts and brownouts (if any), and the penalties for each
- the average power cost to your customers in cents per kilowatt hour

The final screen will report the monthly electricity cost for an average Wattstown family, based on your team effort. Then it will ask if you would like to reduce the cost. You can play again, using what you've learned.

After you've read through the welcome message and general description of game goals, you have a choice: continue the description, or begin to play. If this is your first time playing, you'll want to read the description carefully. It will explain that your job is to provide a continuous flow of power to Wattstown.

### Equipment

- Apple IIe, IIc, II + with 64K memory, or an Apple-compatible computer.
- Monitor.
- Disk Drive.

### Loading

1. Insert "Power Controller" disk, label side up, into the disk drive. If you have more than one disk drive, use Drive 1.
2. Make sure the disk drive door is closed.
3. Turn on the monitor or T.V.
4. Turn on the computer.

WARNING: DO NOT OPEN THE DISK DRIVE DOOR WHEN THE RED LIGHT IS ON.

## Meeting Your Goals

You are the power controller for the Wattstown power facility. Over a 24-hour period, you must meet the demand for electricity in Wattstown. You should find the least expensive way to do this, while still producing enough electricity to keep the town running.

You can buy electricity from four different sources: fossil fuel, nuclear, hydroelectric and pumped storage. Knowing the cost and amount of electricity available from each source will help you decide when to use each one. If you fail to meet the power demand of Wattstown, you will cause a blackout or brownout, and you will be fined.

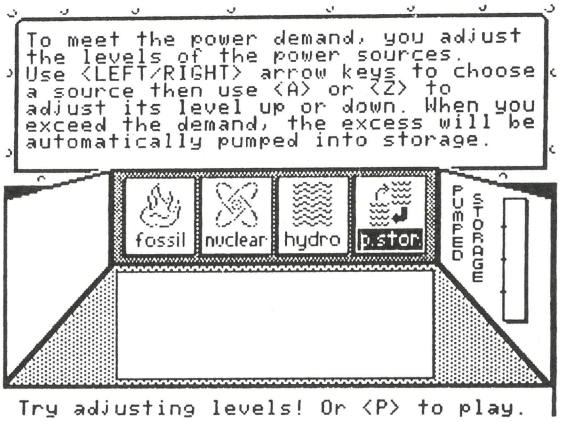
When you see the screen that says "Controller for the Night Shift, type in your first name," enter the first controller's name.* Do the same for the second and third controllers.

If there is only one power controller for all three shifts, press <RETURN> when asked for the names of the second and third controllers. The first controller's name will be entered automatically.

If a name is misspelled, correct it by using the ← key to backspace, then retype.

***Note:** The program will accept a maximum of 27 characters. However, once you exceed 26 characters, you will not be able to correct misspellings.

## How To Play


To meet the power demand, you adjust the levels of the power sources. Use <LEFT/RIGHT> arrow keys to choose a source then use <A> or <Z> to adjust its level up or down. When you exceed the demand, the excess will be automatically pumped into storage.
fossil
nuclear
hydro
p.stor
PUMPED STORAGE
Try adjusting levels! Or <P> to play.

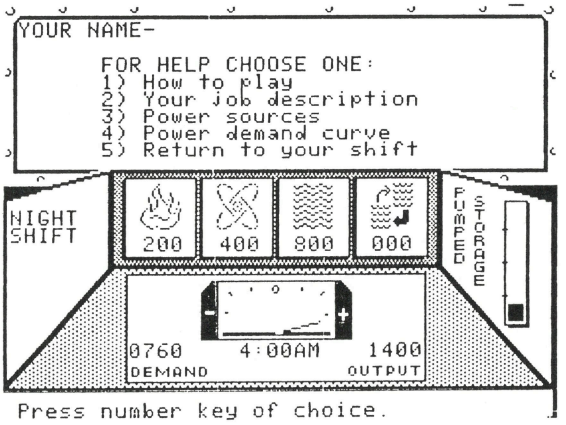
Look at the sample screen above. The four windows show symbols for the four power sources, with the names of the sources below them. Later, the names are replaced by numbers that tell how much power is being supplied by each source.

To find out the maximum for a source, use ← and →keys to choose the source. Each press of the <A> key raises the power supply by 100 MW. Each press of the <Z> key lowers the power supply by 100 MW.

For example, go to the fossil fuel source. Keep pressing the <A> key until you see the word MAX (maximum). That is the most electricity the fossil fuel source can supply.

Now, choose another source and do the same.

At any time during the simulation, you can press the <ESC> key for help. When the help menu appears, press the <1> key, "How to Play," and you will see the screen that appears on the next page.




Look at the meter at the bottom of the screen. Directly under the meter, you see the time of day. To the left of the meter there is a number that tells you how much electricity Wattstown needs at that time. To the right there is a number that tells you how much electricity you are supplying.

The power output (the number on the right) must be equal to, or greater than, the town's power demand (the number on the left). If the output and demand are equal, the needle on the meter will be centered (at zero).

## Brownouts And Blackouts

If the output falls 1% to 10% below demand, you will cause a brownout in Wattstown. You will be penalized for each brownout. When you cause a brownout, you must raise the power output to meet the demand level before the time of day changes by 10 minutes, or you will be charged for another brownout.

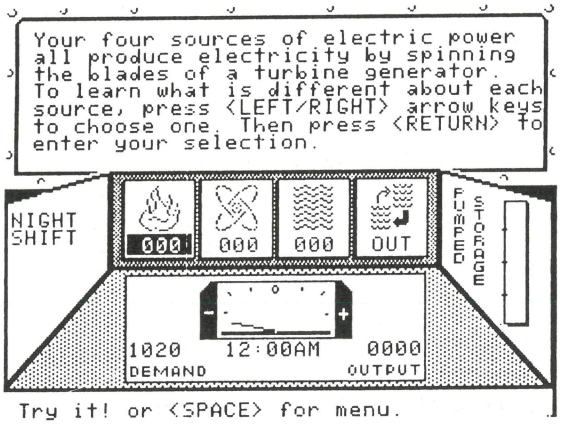
When you are in a brownout, and you want to know what's happened, press the <W> key for "What's a brownout?" All action will stop. You will then have a chance to fix your power levels before the clock starts again.

If the output falls more than 10% below demand, you will cause a blackout in Wattstown. You will be penalized for each blackout. When you cause a blackout, your screen will go dark and all action will stop. Before the clock begins again, you'll have time to raise your output to meet your demand. If your output is less than your demand when you press <SPACE> to start the clock, you will cause another blackout or a brownout.

When you have caused a blackout, press the <W> key for "What's a blackout" to get a definition of a blackout.

In order to avoid brownouts or blackouts, study the demand curve by pressing the <4> key on the menu.

## Power Sources


Your four sources of electric power all produce electricity by spinning the blades of a turbine generator. To learn what is different about each source, press <LEFT/RIGHT> arrow keys to choose one. Then press <RETURN> to enter your selection.
NIGHT SHIFT
000
000
000
OUT
PUMPED STORAGE
1020
12:00AM
0000
DEMAND
OUTPUT
Try it! or <SPACE> for menu.

This is very important information. Each power source is described for you, including the maximum amount available from each source in this simulation.

Wattstown uses four sources of electricity: fossil fuel, nuclear, hydroelectric and pumped storage.

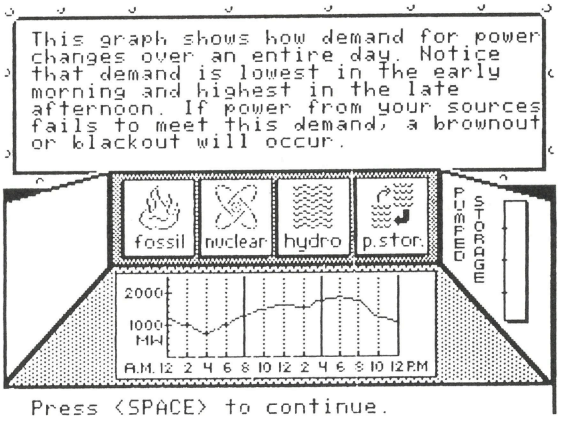
Each power source uses a different form of energy to spin the blades of the turbine-generators. A fossil fuel plant burns oil, gas or coal; a nuclear plant uses the power of the atom; and a hydroelectric plant uses falling water.

Pumped storage is a special kind of power source. It involves using excess electricity from other power sources to pump water from a lower reservoir to a mountaintop (upper) reservoir. Then, during the hours of peak demand, the water is allowed to run back down to create hydroelectric power.

The electricity output of a pumped storage plant depends on the amount of water in the upper reservoir. The amount of electric power is limited by the storage capacity of the upper reservoir.

Find out the maximum output and the cost for each power source by pressing the <3> key, "Power Sources," on the menu.

## Demand Curve


This graph shows how demand for power changes over an entire day. Notice that demand is lowest in the early morning and highest in the late afternoon. If power from your sources fails to meet this demand, a brownout or blackout will occur.
fossil
nuclear
hydro
p.stor.
PUMPED STORAGE
2000
1000
MW
A.M. 12 2 4 6 8 10 12 2 4 6 8 10 12 P.M.
Press <SPACE> to continue.

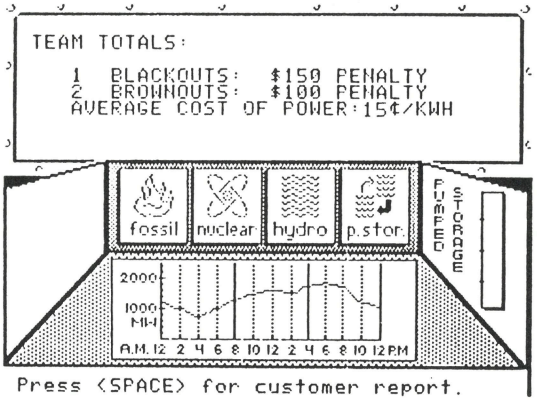
When you read the introduction, you saw a graph called a Demand Curve. It's very important to understand how this relates to the "Power Controller" simulation. Look carefully at the graph. On the left, the megawatts of power are listed. Under the graph are two-hour periods of time. The line that runs through the graph looks like a mountain with two peaks. One high point occurs at noon, and the highest is at 6:00 P.M.

During each shift it is possible to produce more power than Wattstown needs at that time. Whenever your output is larger than your demand, water will be pumped into storage automatically. (Your teacher will explain the efficiency rate of pumped storage.) But remember, the more expensive the fuel you are using to pump, the more expensive your pumped storage energy will be.

Watch the pumped storage symbol carefully and you will see the arrows blink. The left arrow blinks when you are pumping water. The right one blinks when you are using your pumped storage energy. Look to the right of that symbol and you will see the pumped storage gauge begin to rise. Good work! You're storing power that you can then draw upon during peaks in the demand curve when the other three sources cannot produce enough electricity to meet the demand.

## TEACHER SECTION

Welcome to "Power Controller." This simulation puts three of your students in control of a large power facility for a 24-hour period (three eight-hour shifts). They will learn about four different sources of electricity (fossil fuel, nuclear, hydroelectric and pumped storage), the amount of power that each produces, and the cost of each one. They must decide which source will give them the most electricity for the least amount of money and which sources to use at different times of the day. They'll see how the demand for electricity changes at various times during the day and night. If the amount of power provided isn't sufficient, a brownout or blackout will occur.




When the simulation ends, a chart will appear. It will show:

- The number of blackouts and brownouts (if any)
- The average power cost to customers in cents per kilowatt hour

The final screen will report the monthly electricity cost for an average Wattstown family, based on the team effort. It will then ask if the team would like to reduce the cost. Students can play again, using what they have learned to provide the necessary power to Wattstown more economically.

## Changing the Current Values

```
          CURRENT VALUES

1) SOUND ON
2) COST OF FOSSIL FUEL        15 CENTS/KWH
3) COST OF NUCLEAR POWER      10 CENTS/KWH
4) COST OF HYDROELECTRIC      5 CENTS/KWH
5) COST OF PUMPED STORAGE     5 CENTS/KWH
6) EFFICIENCY OF PUMPED       75 %
                  STORAGE
7) CLOCK DELAY FACTOR:1
8) THIS LINE INTENTIONALLY LEFT BLANK
9) PENALTY FOR BLACKOUTS $150
10)PENALTY FOR BROWNOUTS $50


DEPRESS CAPS LOCK KEY


DO YOU WANT TO CHANGE THESE VALUES?
(TYPE Y OR N)
```

If you press the <CONTROL> and <V> keys immediately after you see the first screen with the words "Press <SPACE>," you will get the Current Values menu. You may change any one or all of the values by following the directions you are given on the screen.* The clock delay factor, No.7, controls the speed of the game. The fastest setting is 1; the higher the number you enter, the slower the game.

** You can return to the original values of the game at any time by restoring defaults.*

## Pumped Storage

It's particularly important for your students to understand the principles of pumped storage. Around the time when the demand is at its highest point (6:00 P.M.), they must have reserve power in pumped storage to meet the demand. Listed below is the essential information about pumped storage:

1. Water is stored in a specially-constructed upper reservoir.

2. When electricity is needed, water is released and falls to the power plant, where turbines turn generators to make electricity.

3. Water is collected from or discharged into a lower reservoir.

4. Water is pumped back to the upper reservoir (using other sources of electricity) during periods of low-energy demand (e.g. during the night) and stored until needed.

Energy storage devices are less than 100% efficient because electricity must be used to pump the water up to the upper reservoir. Pumped storage power plants are usually not more than 75% efficient. That is, if a plant is operating at 75% efficiency, and you use 100 MW to pump the water, you will get back only 75 MW of electricity.

**Note:** Be sure to explain the efficiency rate of pumped storage and let your students know what rate you are using for this simulation.

Also, in this simulation, you are charged for the pumped storage while you are pumping, and its cost is based on the cost of the source you are using to pump. Therefore, the cost of pumped storage power, when it is used, should be less expensive than other available power sources.

## The New York State Department of Education Block I

These materials were prepared for grades six through nine. They are keyed to the Concepts and Understandings of Block I found in the Science Syllabus for Middle and Junior High Schools of the New York Department of Education. Behavioral objectives are also based on this curriculum. The following describes Block I concepts and behavioral objectives in detail.

For your easy reference, these concepts are listed below exactly as they appear in Block I along with appropriate page numbers.

II. Energy Sources of Past and Present (p. 13)

The history of energy sources and use is presented in short, clear paragraphs. The discussion of the major sources of energy supplements the

brief descriptions in the simulation. Footnote 39 on page 25 gives a particularly good definition of pumped storage.

B. Present major sources of energy

1. fossil fuels (p. 18)
2. hydroelectric power (p. 24)
3. nuclear power (p. 25)
4. electricity as a secondary energy source (p. 28)

III. Aspects of Energy Problems in the U.S. (p. 29)

To understand the need for intelligent use of our energy sources in the United States, we must have a clear picture of both the locations of various types of power used and the implications of each.

A. Patterns of consumption

1. by sector (p. 30)
2. by source (p. 31)
3. implications (pp. 32-33)

IV. Approaches to Energy Problems (p. 40)

An educated citizen knows there are a variety of approaches to any problem. To understand the implications of conservation as one approach to energy problems, this section clearly defines the pros and cons.

A. Conservation (p. 41)

4. advantages and disadvantages of conservation (pp. 45-46)

Appendix A - Learning Activities

In the hands-on activities listed below, a wide variety of experiments and observations can be used to show students different aspects of electrical energy.

I-3 Potential & Kinetic Energy Relationships (p. 68)
I-8 Chemical Energy in a Match (p. 70)
I-24 The Energy Content of Oil (p. 78)
I-28 Heat Content of Major Coal Types (p. 81)
I-31 Energy from Falling Water (p. 83)
I-37 Electricity Production (p. 86)
I-38 Turning a Turbine (p. 86)
I-39 Producing an Electric Current (p. 87)
I-42 Energy: Sources and Uses (p. 89)

## Behavioral Objectives

**Operating the Simulation.** When the students complete the simulation, they will be able to:

- Control the town's electricity supply for each one of three eight-hour shifts. By varying the amount of power drawn from each of the four sources, they will meet demand in the most cost-effective way.
- Meet the town's energy demand without causing brownouts or blackouts.
- Use excess power during low-energy demand periods to create pumped storage capacity. During hours of peak demand, when the total output of the three other plants cannot meet the town's energy demands, students will use their pumped storage power.

### Basic Power-Supply Concepts

- Given an electric power demand curve (graph) for a community, students will be able to describe the relationship between demand and time of day.
- Given information on power sources and costs, students will be able to rank each source of electric power in order of increasing cost. (The costs of each source can be changed to reflect the relative cost of each source in the students' community.)
- Given information on the amount of power available from conventional sources (hydroelectric, fossil fuel and nuclear) and the power demand curve (graph), students will demonstrate an understanding of the relationship between pumping water to the upper reservoir during periods of low demand, and using that pumped storage capacity during peak demand times.
- After viewing an animated tutorial on the pumped storage power plant, students will be able to describe each step in the pumped storage process.

## Support Materials

Included in your packet are the support materials listed below.

*Pre-simulation homework:* Students gather data on their own appliances using this home energy survey worksheet to list the wattage of each appliance and the total minutes it is used each day. Using this information, students learn to plot a demand curve of their own home energy use.

*Post-simulation assignment:* Students can use various mediums to trace the historical development of electrical appliances or explore the idea of living today without electrical power.

*Hands-on experiment:* Directions for building a generator model.

## PRE-SIMULATION HOMEWORK ASSIGNMENT

We take electricity for granted. We don't think about how different our lives would be if we didn't have electricity.

Think about the appliances in your home. Each requires a different amount of electricity to run. You may use some of them once in a while and some of them very often. The appliance use in your friends' homes may be very different from your own.

A list of appliances and the common wattage of each appears below. Every electrical appliance must have a label showing the number of watts it uses.

Look at the first four appliances on the list. If you have these appliances at home, look at each of them when you go home tonight. Find the label that tells the number of watts each uses and write that number on the blank line to the right of each appliance on your list. You may notice differences between your numbers and the numbers given to you.

| Common Wattage of Appliances | | Wattage of Your Appliances |
|---|---|---|
| Hairdryer | 1,250 W | _____ |
| Vacuum | 650 W | _____ |
| Television | 150 W | _____ |
| Toaster | 1,150 W | _____ |
| Light | 100 W | |
| Stereo | 150 W | |
| Electric Heat | 7,000 W | |
| Coffee Pot | 900 W | |
| Refrigerator | 600 W | |
| Stove Top | 1,200 W | |
| Oven | 6,000 W | |
| Washer | 1,000 W | |
| Dryer | 5,400 W | |
| Water Heater | 4,500 W | |

Now look at the chart on the next page. It breaks a 24-hour day into 12 two-hour periods, beginning at midnight. For each two-hour period, find out which appliances from the list are used in your home. Write the name of the

appliance in the first column. In the second column, write the amount of wattage the appliance uses. (Use your own numbers when you have them.) Then, record the approximate number of minutes the appliance is used in the third column.

Ask everyone in your household to help you complete the list. Does someone do the laundry at dinner time? Does anyone use the stove to fix a midnight snack?

Multiply the number of watts each appliance uses by the number of minutes the appliance is on. Put the number on the blank line in the right column marked "Total." For each two-hour period, add up the right column, and put the sum in the box marked "Total for Period."

When you complete the chart, you'll see which times of the day you use the most electricity.

## Sample chart

| Time Period | Appliances | Wattage | Minutes | Total | Total for Period |
|---|---|---|---|---|---|
| 6:00 a.m. - 8:00 a.m | Refrigerator | 600 | 11 | 6,600 | |
| | Hairdryer | 1,250 | 5 | 6,250 | |
| | Stereo | 150 | 30 | 4,500 | |
| | Water heater | 4,500 | 15 | 67,500 | |
| | Stove | 1,200 | 10 | 12,000 | 96,850 |

Take the completed chart with you the next time your class meets. Your teacher will show you how to plot a "demand curve" of your own. You may decide to put all the totals from all the lists together and make a demand curve for your class.

Can you think of some other ways to use this information?

| Time Period | Appliances | Wattage | Minutes | Total | Total for Period |
|---|---|---|---|---|---|
| Midnight - 2:00 a.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 2:00 a.m. - 4:00 a.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 4:00 a.m. - 6:00 a.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 6:00 a.m. - 8:00 a.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 8:00 a.m. - 10:00 a.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 10:00 a.m. - Noon | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| Time Period | Appliances | Wattage | Minutes | Total | Total for Period |
|---|---|---|---|---|---|
| Noon - 2:00 p.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 2:00 p.m. - 4:00 p.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 4:00 p.m. - 6:00 p.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 6:00 p.m. - 8:00 p.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 8:00 p.m. - 10:00 p.m. | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| 10:00 p.m. - Midnight | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

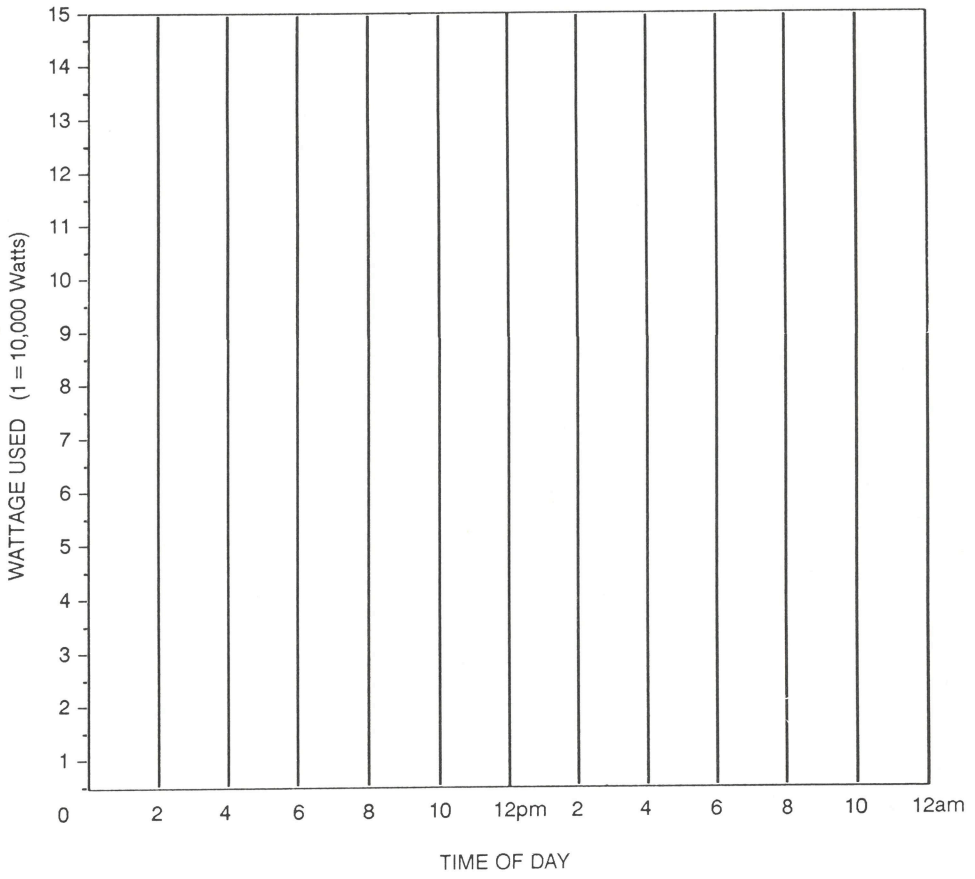
## CLASS ASSIGNMENT

The following assignment introduces students to the concept of electrical energy conservation.

Encourage your students to do this assignment with the other members of their household. Awareness of electrical energy use is important for all of us.

When the students bring the completed charts to class, the information can be plotted on copies of the graph below. If you or some of your students are familiar with computer programs that graph information from a data base, make that into another activity to reinforce the concepts.

**Construct A Bar Graph By Using Data From Your Chart.**



**Collages of the historical development of electrical appliances**

Artistically inclined students may enjoy seeing the changes in design through the years. Or someone may want to photograph old appliances in an antique shop or flea market. If there is a museum that has an exhibit of furnished rooms from earlier decades or centuries, ask students to photograph them and comment about the differences.

**Creative writing**

Students who enjoy writing may want to create a story about how their lives would be different if electrical power suddenly disappeared.

Add your own ideas to the list and share them with students and colleagues in other disciplines.

## BUILDING A GENERATOR MODEL

**Objective:**
To construct a working model of a generator and detect the current it produces.

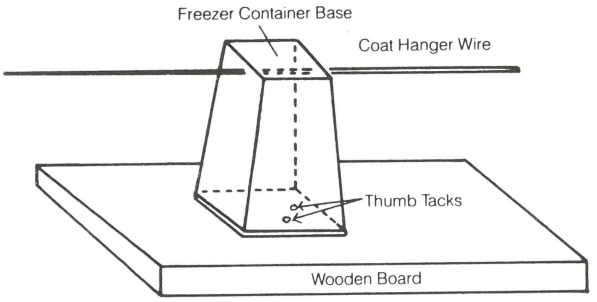
**Materials:**
- Plastic freezer container and lid (3.5" x 3.5" x 5.5")
- Wooden board (9" x 11" x 0.5")
- 3 thumb tacks
- Wire coat hanger
- Masking tape
- Scotch tape
- Bar magnet (4" long)
- Paper clip
- Plastic curler with clip (1" to 1.25" in diameter)
- #30 gauge enameled-copper wire
- Matches
- Galvanometer (directions for this follow)

**Tools:**
- Pliers
- Wire cutter
- Awl

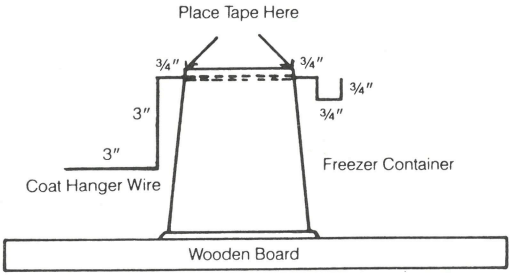
**Directions:**
*Step 1* - Position the lid from the plastic freezer container up-side-down on the wooden board. Secure the lid to the board by pushing three thumb tacks through the lid and into the board.

*Step 2* - Snap the freezer container into its lid. Use the awl to punch a hole in the middle of one side of the container near its original base. Punch a second hole in the container, opposite the first.

*Step 3* - Snip a long straight piece from the wire coat hanger with the wire cutter. Slide the wire through the holes in the freezer container.




*Step 4* - Bend the wire into the desired shape with pliers. Use the diagram below as a guide. Secure this axle by wrapping a 5" piece of masking tape around each 3/4" length of wire protruding from the container. The axle should turn freely, but not slide back and forth through the holes.



# ELECTROMAGNETIC CIRCUIT BREAKER MODEL

**Objective:**
To construct a working model of an electromagnetic circuit breaker.

**Definition:**
A circuit breaker is a device that automatically opens a circuit, shutting off the flow of electricity when an overload is about to occur. Every circuit has a limit to the amount of electric current it can handle. If that limit is exceeded, the heat could cause a fire or other damage to the circuit. The circuit breaker, therefore, protects the circuit.

**Materials:** (all supplies can be purchased from a hardware store and an electronics store)

- 16" x 12" pegboard (3/16" hole every inch)
- 4 cell battery holder
- 4 "D" batteries
- 2" carriage bolt and nut (steel)
- #22 gauge enameled copper wire (spool of about 40')
- Masking tape
- Knife switch
- 16 alligator clips
- 8 microlamp bulb sockets
- 8 microlamp bulbs
- Aluminum sheet metal (from aluminum flashing)
  1 piece – 2 3/4" x 1/4"
  2 pieces – 7 1/2" x 1"
- Tin sheet metal (from tin can)
  1 piece – 2" x 1/4"
- Assorted nuts and bolts
  20 – 3/4" (#8)
  5 – 1/2" (#10)
  6 – 1" (#10)
- 6 one-hole rubber stoppers
- Bell wire (one roll of about 25')

**Tools:**

- Screwdriver
- Tin snips
- Emery board
- Hammer
- Nail
- Needle-nose pliers

**Directions:**

The circuit breaker consists of an electromagnet and a metal paddle sitting on an aluminum coil. When too many lights are turned on at once, the current increases and the electromagnet becomes strong enough to pull the metal paddle off the aluminum coil. This opens the circuit, and the lights go off. To reset the circuit breaker so electricity will flow again, you need to do two things: (1)turn off the lights and (2)replace the metal paddle on the aluminum coil.

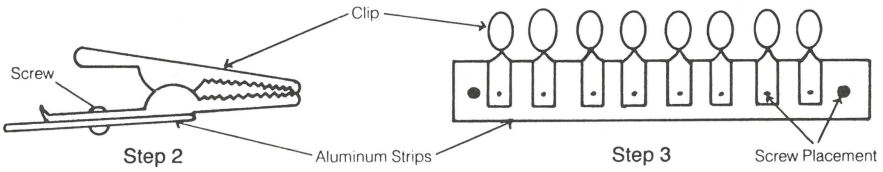
You will need to make three pieces to the model before the circuit breaker can be assembled. The directions for these three pieces are as follows:

- Alligator Clip Holders
  Use the two aluminum pieces that measure 7 1/2" x 1"

  *Step 1* - Punch eight equidistant holes in each piece with a nail and hammer.

  *Step 2* - Fasten an alligator clip in each hole with the screw that comes with the clip. If the holes in the aluminum strips are too small for the screws, they can be enlarged slightly with the end of a screwdriver.

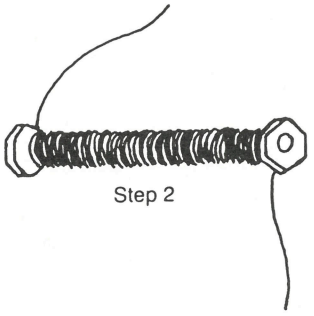
*Step 3* - Punch two more holes at the ends of the aluminum strips. These are the screw holes so the alligator clip holders can be anchored to the pegboard.




- Electromagnet
  Use the 2" steel carriage bolt and nut, and #22 gauge enameled copper wire

  *Step 1* - Turn the nut onto the bolt just far enough to cover the end.

  *Step 2* - Start 3" to 4" from the end of the wire and wind it around the threads of the bolt. Keep the windings as close together as possible. When the wire touches the opposite end of the bolt you have made one layer of coil. Make three more layers of wire coil over the first. Again, keep the windings as close together as possible.



*Step 3* - When finished, cut the wire 3" to 4" from the last coil on the bolt.

*Step 4* - Wrap masking tape over the top layer of wire to hold it in place.

*Step 5* - Scrape about 1" of enameling from the two ends of the wire with an emery board or screwdriver.

- Coil and Paddle Circuit Breaker

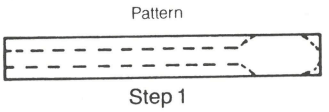
*Paddle.* Use the tin piece that measures 2" x 1/4"

*Step 1* - Trim the tin piece with tin snips into a paddle shape. Use the pattern below as a guide.

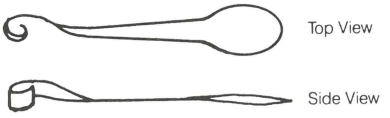
*Step 2* - Use needle-nose pliers to bend the narrow end of the paddle into a small loop. The loop must fit loosely around a #8 bolt.

*Step 3* - Place the looped end of the paddle on a table top so one edge touches the table. Hold the loop down against the table with one finger and twist the wide paddle end 1/4 turn with your other hand.

*Step 4* - Smooth the rough edges of the wide paddle with an emery board.




Step 1




Step 3

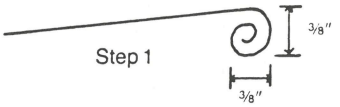
*Coil.* Use the aluminum piece that measures 2 3/4" x 1/4"

*Step 1* - Form a coil by winding 1" of the aluminum strip around the shaft of a bolt. Remove the bolt from the center of the coil. Gently loosen the curl so its outside diameter is 1/4" to 3/8".

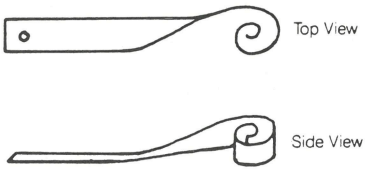
*Step 2* - Punch a hole in the flat end of the aluminum strip with a nail and hammer. Enlarge the hole with the end of a screwdriver so a 1/2" bolt will fit through it.

*Step 3* - Place the aluminum piece on a table top so one edge of the coil touches the table. Hold the coil down against the table with one finger and twist the opposite end (with the hole) 1/4 turn with the other hand. The end with the hole should now lie flat on the table.

*Step 4* - Smooth the rough edges of the coil with an emery board.



Step 1



Step 3

**Pegboard Assembly**

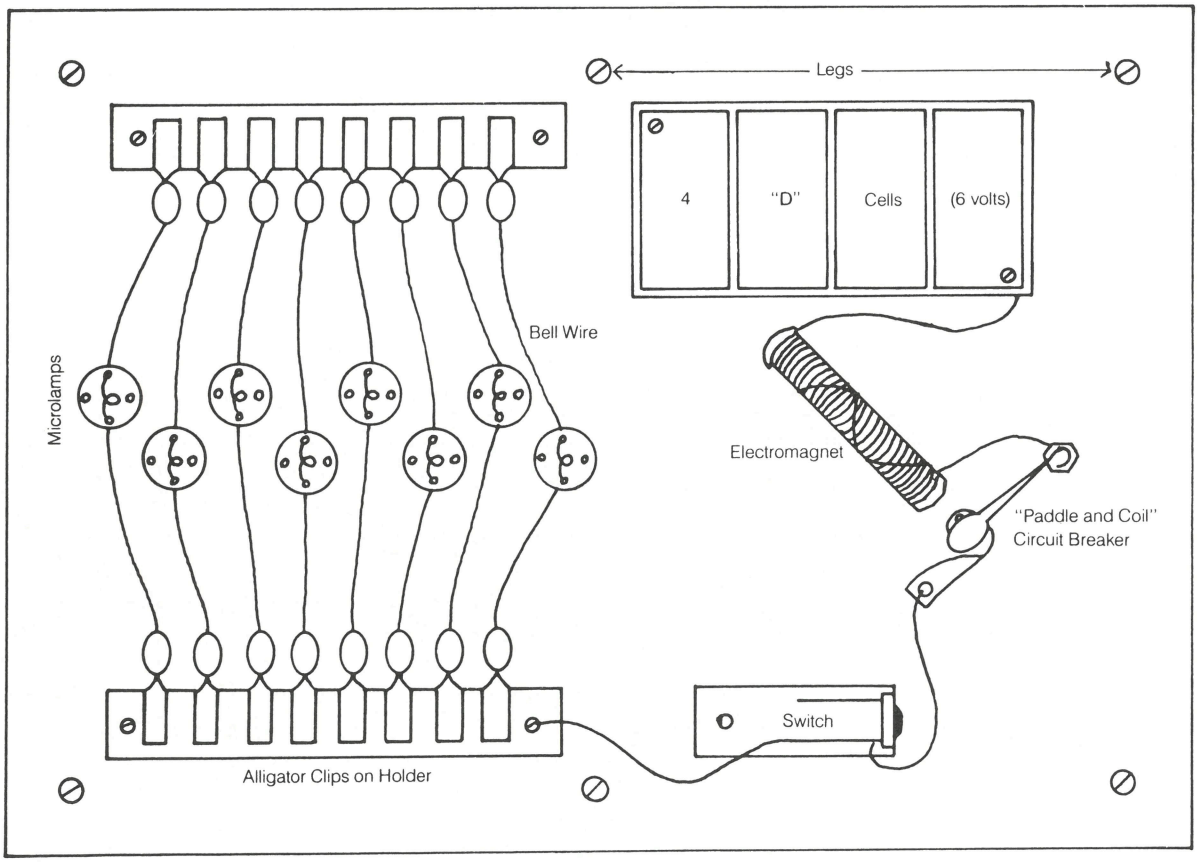
Refer to the diagram below for placement of the circuit parts on the pegboard. Below are some special instructions, which you may find helpful:

1. Anchor the electromagnet to the pegboard by threading string or extra wire through the board holes and around the electromagnet. Twist the wire ends together on the back of the pegboard.
2. To make the electrical contact for the paddle, slide a #8 bolt up through the bottom of the pegboard and anchor it with two nuts. Two nuts are used to elevate the loop of the paddle to the desired height.
3. Cut 18 pieces of bell wire between 3" and 4" in length. The exact lengths you need will be determined by the arrangement of the circuit parts on

the pegboard. You may wait to cut the bell wire until after the circuit parts are screwed into place on the board. Remove approximately 1" of insulation from each end of the wires.

4. One-hole rubber stoppers may be slipped over the 1" bolts used as legs. This will protect the table top and also keep the pegboard from sliding.

5. To enable you to change the number of resistances in the circuit, the wires held by the alligator clips can be either inserted or removed.




⊘ Indicates Placement of Nut and Bolt to Anchor Circuit Part to Pegboard

## " A DAY WITHOUT ELECTRICITY "

Organize "A Day Without Electricity" to give students a unique, first-hand view of the importance of electricity in modern life.

The ideal location for this program is a local historic site, where students can get a sense of how people lived and worked before electricity was invented. Also, trained staff are on hand to teach the crafts and occupations of the period. However, if you don't have access to an historic building, conduct the program in your school.

Plan activities that focus on the conveniences of modern appliances, drawing parallels between life with and without electricity. Refer to appliances used in the simulation. For example: how people kept warm before there were electric heaters, cooked food without modern ovens, and entertained themselves before the age of stereos and televisions.

Students can prepare a meal for fellow students on an open hearth using period recipes, ingredients and equipment. Or they can learn to use basic coopering tools to make a bucket. Other things they can learn include textile production, milling and wood technology.

The day can be topped off with an exciting and historic activity, such as a candlelight tour of the building, an authentic dance or "frolic," or a sing-a-long of period music.

Remember that the program need not be confined to your science curriculum. You can structure it to include social studies, technology, literature or any other discipline that you see fit.

Following the outing, students can monitor their own household's electricity use. The pre-simulation assignment in this packet may prove useful for this. Also, you may want them to write essays on their thoughts and interpretations of the value of electricity in modern life.

# FURTHER READING ON ELECTRICITY

## Teacher References

Berger, Melvin. (1983). **Energy: A Reference First Book**. Franklin Watts: New York/London/Toronto/Sydney.

This book contains detailed descriptions of energy terms, including all of those referring to electricity.

Vogt, Gregory. (1985). **Electricity and Magnetism.** Franklin Watts: New York/London/Toronto/Sydney.

This book contains the history of electricity and magnetism, and information about the atomic theory. It discusses the concepts of conduction, serial and parallel circuits, volts, amperes and power rules. Directions for student experiments are included.

## Student References

Here are a few books that will tell you more about electricity:

Boltz, C.L. (1985). "**How Electricity Is Made.**" Facts on File Publications: New York/Bichester, England.

You'll find all the basic information you need to understand electricity. There's a description of how we get electricity from the wind, the sun, atomic power and other sources. Another section describes the atom and what it has to do with electricity. It explains how electricity comes into your home from a power station and the amounts of energy used by home appliances. In the back is a glossary of terms.

Epstein, Sam and Beryl. (1977). **Saving Electricity.** Garrard: Champaign, Illinois.

You may want to use this book to review and expand the ideas you saw in "Watts in a Home." It will explain the importance of electricity in our lives and the generation of electricity by magnetism. Once again you'll find watts and

kilowatts explained as measures of electrical power. You're given detailed explanations of watt usage for household appliances (sound familiar?) and ideas on ways to conserve energy in the home. Then there's information on the effects of energy usage on the environment.

Epstein, Sam and Beryl. (1977). **The First Book Of Electricity.** Franklin Watts: New York/London.

This book, too, gives you some elementary explanations -- the atomic theory of electricity; magnetism as related to electric currents; definitions of volts, amperes, watts and kilowatts as measures of electrical power. Home usage is here too -- electrical wiring in the home, including safety devices such as fuses and circuit breakers, and how electricity makes certain home appliances operate. In addition, one section tells you how industry generates and distributes electricity to homes. A glossary of terms is in the back.

## GLOSSARY

**Blackout:** Total loss of electric power to a house or a neighborhood.

**Circuit Breaker:** A device that automatically opens a circuit, shutting off the flow of electricity, when an overload is about to occur. Every circuit has a limit to the amount of electric current it can handle. If that limit is exceeded, the heat could cause a fire or other damage to the circuit. The circuit breaker, therefore, protects the circuit.

**Cyclical Appliance:** An appliance that turns on and off automatically in order to maintain a steady temperature. Refrigerators and water heaters are typical examples of cyclical appliances.

**Kilowatt (KW):** 1,000 watts. Since a watt is a very small unit, "kilowatt" is usually used to figure out a household's electricity use.

**Kilowatt Hour (KWH):** One kilowatt of electricity for one hour. For example, the use of ten 100-watt light bulbs for one hour will consume one kilowatt hour of electricity (1,000 watts, or one kilowatt, for one hour).

**Watt:** The basic unit used to measure electrical power.